Ministry
of
Education
Ontario

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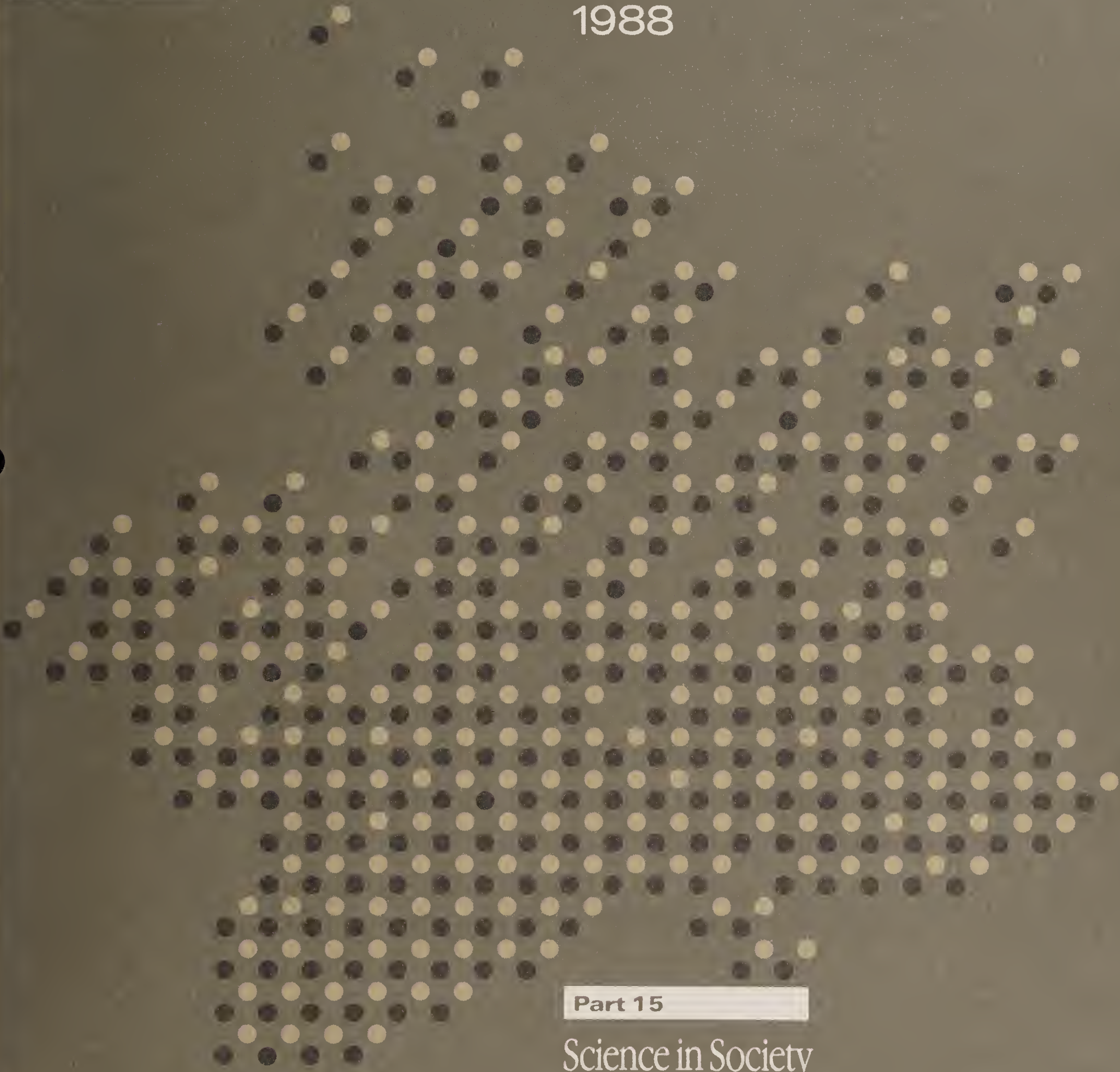
Curriculum Guideline

Science

Intermediate and Senior Divisions

1988



Part 15

Science in Society

OAC

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Introduction

The Parts of the Guideline

This document is Part 15 of a fifteen-part curriculum guideline that outlines the science program for the Intermediate and Senior Divisions in Ontario schools and describes the science courses that can be offered (see the list of courses and their course codes in Appendix A). The term *guideline* refers to the entire set of fifteen parts.

This part must be read and implemented in conjunction with Part 1, *Program Outline and Policy*. When implementing the courses that are described in this document, teachers are to incorporate the many policies and features outlined in Part 1, which will enable them to interpret the overall intent and expectations of the Ministry of Education in the science program. The table of contents for Part 1 is given in Appendix B at the end of this document so that the reader may have ready access to the list of chapters and topics therein.

The provincial science program for the Intermediate and Senior Divisions comprises the courses described in Parts 2 to 15. These come under the framework and policy set forth in Part 1. The entire science guideline consists of the following fifteen parts:

Part 1: Program Outline and Policy
Part 2: Science, Grades 7 and 8
Part 3: Science, Grades 9 and 10, General Level
Part 4: Science, Grades 9 and 10, Advanced Level
Part 5: Science, Grades 9 and 10, Basic Level
Part 6: Science, Grades 11 and 12, Basic Level
Part 7: Environmental Science, Grades 10 to 12, General Level
Part 8: Environmental Science, Grades 10 and 12, Advanced Level
Part 9: Applied Biology and Applied Chemistry, Grade 11, General Level
Part 10: Applied Physics and Technological Science, Grade 12, General Level
Part 11: Geology, Grade 12, General and Advanced Levels
Part 12: Biology, Grade 11, Advanced Level, and the OAC
Part 13: Chemistry, Grade 11, Advanced Level, and the OAC
Part 14: Physics, Grade 12, Advanced Level, and the OAC
Part 15: Science in Society, OAC

The chart on the next page indicates the twenty-eight science guideline courses that may be offered in Grades 7 to 12 and at the OAC level.

Policies and Features That Apply Across the Science Program

Part 1 of the guideline specifies a great number of the policies and features that are to be integrated into the design of the science program in the Intermediate and Senior Divisions. There are too many of them to describe in full in each of Parts 2 to 15, but the following points will give the reader some idea of the scope that is involved. They include:

- information about the science credits that are required for the earning of the Ontario Secondary School Diploma;
- a list of science courses that are prerequisite to other science courses;
- the policy regarding mandatory student activities in the science laboratory;
- a list of the aims of the science curriculum and the various emphases that may be used to blend these aims with scientific content;
- policy governing time allocations for units of study and the order in which core and optional units may be taught;
- stipulations about locally designed units;
- suggestions about preferred routes that students might take through the science program in a secondary school;
- recommendations related to exceptional students, individualized instruction, life-management skills, career awareness, the role and evaluation of language in science courses, and a balanced perspective on the role of both girls and boys in science;
- recommendations on the introduction and handling of sensitive issues;
- specific suggestions about resources for the teaching of science;
- ideas about different modes of delivering science courses, including the co-operative education mode;

Authorized Science Guideline Courses, Intermediate and Senior Divisions

	Basic Level	General Level	Advanced Level
Grade 7	Science		
Grade 8	Science		
Grade 9	Science (SNC1B)	Science (SNC1G)	Science (SNC1A)
Grade 10	Science (SNC2B)	Science (SNC2G) Environmental Science (SEN2G)	Science (SNC2A) Environmental Science (SEN2A)
Grade 11	Science (SNC3B)	Applied Biology (SBA3G) Applied Chemistry (SCA3G) Environmental Science (SEN3G)	Biology (SBI3A) Chemistry (SCH3A)
Grade 12	Science (SNC4B)	Environmental Science (SEN4G) Geology (SGE4G) Applied Physics (SPA4G) Technological Science (STE4G)	Environmental Science (SEN4A) Geology (SGE4A)* Physics (SPH4A)
OACs			Biology (SBI0A) *Prerequisite* – Biology (SBI3A) Chemistry (SCH0A) *Prerequisite* – Chemistry (SCH3A) Physics (SPH0A) *Prerequisite* – Physics (SPH4A) Science in Society (SSO0A) *Prerequisite – One of:* Biology (SBI3A) Chemistry (SCH3A) Environmental Science (SEN4A) Geology (SGE4A)* Physics (SPH4A)

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*Since the Grade 12 advanced-level geology course described in the guideline (see Part 11) may be taught under the aegis of a geography department as Geology (GGE4A) – note the course-code change – then either Geology (SGE4A) or Geology (GGE4A) may count as a prerequisite to Science in Society (SSOOA).

- policy pertaining to the significant role to be played by measurement and metric units in science courses;
- stipulations related to the treatment of symbols, significant digits, and mathematical problem solving;
- recommendations concerning the roles to be played by calculators and computers in science courses;
- specific directions about safety;
- policy and principles pertaining to the evaluation of student achievement;
- policy regarding differences in the treatment of science courses at the three levels of difficulty;
- many suggestions about implementing the science program.

It cannot be emphasized strongly enough that teachers of science must integrate the policy and recommendations outlined in Part 1 with the teaching of science and cannot simply rely on the course descriptions given in Parts 2 to 15 of the guideline.

The Science Curriculum Continuum

By the time students have reached the Senior Division they will have experienced first a *unified* approach in the Primary and Junior Divisions, in which science is related to a number of other subject areas, and then a *diversified* approach to a mosaic of science disciplines – biology, chemistry, physics, and environmental science – in the Intermediate Division. In the Senior Division they are provided with a *specialized* approach, in which the science courses deal with a single discipline at a time.

Although these approaches – unified, diversified, and specialized – provide different ways of dealing with the subject, the intention is to ensure that there is a continuum throughout the years. This course develops concepts through experimentation, discussion, research, critical thinking, and the analysis of data.

Teachers of this course should be aware of the subject matter contained in the science units of the Intermediate Division courses and of the way in which the Senior Division courses relate to one another and form a foundation for the Science in Society OAC.

In all science courses the core units and the prescribed number of optional units, if any, are to be included. The time allocation for each unit of study should act as a guide in helping teachers devote an appropriate amount of time to each of the units in a course. This is important in view of the continuum from one course to another and to postsecondary science programs.

Compulsory and Prerequisite Courses

In the secondary school program two science courses are among the compulsory subjects required for the earning of the Ontario Secondary School Diploma. The design of the Science in Society course presupposes a knowledge of the subject matter in the Grade 9 and 10 advanced-level science courses. A Senior Division advanced-level science course is also a prerequisite for this course.

Curriculum Emphases

It is recommended that teachers organize each of the courses described in this document around a particular curriculum emphasis or set of emphases. Such emphases give the curriculum a special focus that can be introduced in addition to the content and processes outlined in the courses. This approach is discussed in subsection 3.4, "Curriculum Emphases – Blending Curriculum Aims With Content", of Part 1 of the science guideline. In table 2 in that subsection a list of emphases is given. These emphases will enhance the development of the science courses described in this document. A particular emphasis that is stressed throughout an entire course or for one or more units at a time needs to be highlighted so that it becomes a focal or integrating theme.

Student Activities

In each unit of study there is a section entitled "Student Activities". This section indicates the *mandatory* laboratory activities required of students. Teachers may substitute *equivalent* laboratory activities where appropriate. Those activities that are actually to be performed by students themselves are marked with asterisks. If time and circumstances permit, the teacher should encourage students to do some or all of the unmarked activities as well. However, such activities may be demonstrated by a student or the teacher or may be discussed in conjunction with a textbook, film, computer program, or other learning material used as a resource. In any event, the scientific concepts and principles related to such unmarked activities and identified in the objectives of the unit of study shall be considered to be part of the prescribed course.

Generally, the best approach to the teaching of science is to ensure that the content develops directly from related student activities. In each unit of study the skills and processes of scientific work should be presented as the central component, from which the subject matter, applications, and implications emerge.

Safety

Safety awareness must be developed in all science students. Constant attention to accident prevention is to be stressed in all student activities and teacher demonstrations in the laboratory. Section 9, "Safety", of Part 1 of the science guideline contains the following comprehensive subsections:

- Safety in the Laboratory
- Some Recommended Safety Procedures
- Animal Care in Science Courses
- The Safe Use of Plants

In each unit of study, subsection 6, "Safety Considerations", acts as a reminder of some of the safety features that pertain to the unit in question. General reference, however, should constantly be made to the safety section in Part 1. Schools must always remain on the alert in regard to safety and maintain an up-to-date safety-awareness program.

Sensitive Issues

The curriculum outlined in this science guideline places a distinct emphasis on the science-technology-society connection. For this reason scientific applications and societal implications are mandatory components of each unit of study. In addition, Part 1 of the guideline underlines the need to incorporate morals/values education into science courses. Undoubtedly, this will give rise to the discussion of some sensitive issues.

Such discussions are important. Generally, they should be focused and should provide an open forum for the expression of different viewpoints. In this regard teachers of science are urged to familiarize themselves with section 10, "Values in Science Education", of Part 1 of the guideline and to pay particular attention to the principles to be observed when dealing with sensitive issues in the science curriculum. These principles are mentioned in subsection 10.2 of Part 1.

Locally Designed Units

The provision for a locally designed unit (LDU) is included as an optional unit in this course to allow teachers, at their discretion, to introduce an appropriate new area not described in the guideline, to expand on previous units or topics by adding new work, or, by using the time allocated to the LDU, to extend the time allocations for the core units. (See also Part 1, subsection 5.5.)

Evaluation of Student Achievement

Particular attention must be paid to the opening policy statements made in section 14, "Evaluation", of Part 1 of the guideline. The evaluation of student achievement in all Intermediate and Senior Division science courses must include certain components, as follows:

- laboratory activities and reports .... at least 15 per cent

and, in addition, for the OACs:

- independent study .... at least 10 per cent
- one or more formal examinations ....30 to 40 per cent

In each unit of study described in the course outlined in this document, section 5, "Evaluation of Student Achievement", specifies certain items that must be included in students' term marks (exclusive of formal examinations) when their achievement is evaluated. In most units teachers are required to evaluate students' activities and related laboratory reports. However, the proportion of the mark assigned may vary from one teacher to another. In order that the experimental component of science be emphasized, the overall mark for an entire science course must include at least 15 per cent for the evaluation of student achievement in laboratory skills and reports.

Cross References

In the descriptions of each unit of study in the course outlined in this document, cross references are provided in parentheses. These are included to provide some examples of the relationships that exist among the parts of the unit.

Particular Features of Science in Society, OAC

Units of Study and Their Time Allocations

The following chart provides an overview of the units of study in Science in Society, OAC. It also indicates the time to be allotted to each unit.

Science in Society, OAC (SSOOA)

Units of Study	Time Allocations
Core	
1. The Nature of Science	20 h
2. The Nature of Technology	20 h
3. Humans in the Environment	20 h
4. Current Issues in Science	30 h
	90 h
Optional	
Locally Designed Unit	20 h
	110 h

If a local unit is not done, no more than seven hours should be added to each core unit.

The Purpose of Science in Society, OAC

Science in Society is a course for both avid science students and students who have an interest in science as it affects society. Science-oriented students will increase their knowledge of aspects of science that are not normally emphasized in courses that are focused on individual science disciplines. Such aspects include the contribution and responsibility of science and scientists to society; the influences of societal forces such as economics, values, and politics on scientific research; and the historical development of modern scientific knowledge. In addition, since this course is an interdisciplinary approach to science, science-oriented students will be exposed to an integrated perspective on science.

Students not specializing in science will, in addition to the above, increase their understanding of science, its methods, and its knowledge, which will assist them in becoming informed problem solvers and decision makers. They will also learn something about the role of science and technology in society.

This course is essentially concerned with developing concepts through experimentation, discussion, research, critical thinking, and analysis; it is not designed primarily to instil a specific body of knowledge. Roughly speaking, the course should deal with scientific content and processes for about 70 per cent of the time and with related societal concerns for the remaining 30 per cent. Each student should be encouraged to discuss and reflect on his/her experience and viewpoint regarding the role of science and technology in the varied aspects of society, past and present.

The emphasis in this course is designed to produce students who are well versed in the issues surrounding science and technology and are able to analyse them critically. The course will provide students with the opportunity to develop introductory research skills involving a wide range of materials and enable them to report and defend their findings in both oral and written form. They will also develop a historical perspective that should allow them to compare present trends and attitudes with those from the past, and they will be encouraged to develop their ideas about the future impact of science on society.

Since there are many different viewpoints and opinions on any specific issue, students should be encouraged to be sensitive to the values and views of others whenever they are proposing solutions to problems. A major aim of the course is to increase understanding of the complex issues facing our society among a broad range of students, who will be our future lawyers, business people, politicians, educators, and citizens.

Some Suggestions for Teaching and Evaluation

This course of study is intended to satisfy a number of diverse needs: the raising of science and societal issues; the inclusion of Canadian content; the development of the learner's intellectual independence, self-awareness, and self-confidence; and the application of scientific knowledge in a variety of technological fields. How can teachers do justice to this variety of curricular demands and also convey a prescribed amount of content material within the limitations imposed by the classroom setting? Two important ingredients are involved in arriving at an answer to this question: (a) the concept of teaching as instruction and (b) curriculum emphases.

Teaching can be thought of as a continuum, beginning with conditioning, passing through training and instruction, and ending with indoctrination. Instruction is the approach to teaching that is most consistent with ministry guidelines. It involves giving reasons, evidence, arguments, and justification for the purpose of helping someone achieve understanding. In science teaching, instruction shifts the emphasis from having students learn science to having students learn *about* science.

The aim of teaching as instruction is to enable students to acquire some sophistication with regard to science as a discipline in relation to other disciplines. In this context it is conceivable that issues such as creation might be taught in a science classroom. The reason for doing this would be to demonstrate how scientific and religious explanations differ. In other words, it would be a pedagogical vehicle for helping students understand one world view by comparing it to another. From this perspective the role of teaching is to help students understand the nature and function of explanation.

The teaching of science *content* must go hand-in-hand with a purpose or *intent*. While the content specifies *what* is to be taught, the intent deals with the issue of *why* the content is to be learned. This is addressed through the curriculum emphasis, which has been explained as follows:

> A curriculum emphasis in science education is a coherent set of messages to the student about science (rather than within science). Such messages constitute objectives which go beyond learning the facts, principles, laws and theories of the subject matter itself – objectives which provide answers to the student question: "Why am I learning this?"*

A particular curriculum emphasis such as *science, technology, and decisions* allows a teacher to combine a number of diverse orientations into a focused, "coherent set of messages" which can be passed on to students. For example, the science, technology, and decisions emphasis enables teachers to come to grips with important considerations such as the strengths, weaknesses, and limitations of science; how science can inform societal decisions; the intellectual independence of the learner; and the skills involved in problem solving.

It is intended that a number of appropriate curriculum emphases be used during the teaching of this course, to allow for the incorporation of as many reasons for the inclusion of the course content as possible.

Evaluation in this course may diverge from the traditional methods usually followed in specialized science courses. Testing for factual knowledge should be based on the relevance of the knowledge to an issue that is being addressed. The quality of pertinent findings and their analysis, and the clear expression of ideas, both orally and in writing, should be emphasized.

Students can be evaluated on the amount, variety, and relevance of the material that they locate on a specific issue. Activities of this kind not only acquaint students with the wide range of materials available but also develop their research skills and provide the teacher with a fund of material that may be incorporated into future courses.

Examinations may be of the open-book variety or may require students to react to previously unseen readings and articles about issues discussed in class. Visual material (e.g., cartoons, slides, videotapes, films) that requires comment and analysis can also be employed on examinations.

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*D. Roberts, "Developing the Concept of 'Curriculum Emphasis' in Science Education", *Science Education*, vol. 66, no. 2 (April 1982), page 245.

Science in Society, OAC (SSOOA)

Core Units

The Nature of Science
The Nature of Technology
Humans in the Environment
Current Issues in Science

(90 hours)

Optional Unit

Locally Designed Unit

(20 hours)

Core Unit 1

The Nature of Science

Time: 20 hours

The purpose of this unit is to initiate an inquiry into the nature of science as described in subsection 3.2 in 1 of Part 1 of the guideline. It provides students with a historical perspective on scientific knowledge so that they can appreciate the significance of scientific achievements in the context of the society in which they occurred. As well, it offers them a framework for analysing the causal assumptions that are made in documenting historical influences on science. The unit will also explore the interaction of societal forces and the role of scientists as members of society.

An understanding of scientific procedures and principles will aid students in making informed decisions about the nature and direction of future scientific research. As well, issues of current interest in such areas as the environment, nuclear energy, bioethics, germ warfare, and medical research can be examined to stimulate discussion on both the impact of science on society and the impact of society on science.

This unit may be divided into topics such as the following:

- The nature of scientific knowledge
- Processes of science and the development of scientific theories
- The use of scientific knowledge and processes in problem solving and decision making
- The impact of science on society, past and present
- Public images of scientists and the contribution of scientists to society

1. Objectives

Attitudes. Students will be encouraged to develop:

a) an appreciation that scientific knowledge is tentative, that its development is influenced by its historical context, and that it is under constant review and revision (2c);
b) an appreciation that science is based on empirical observation (2a, 2e, 7a);
c) an appreciation that scientific endeavour is the result of the insatiable curiosity of human beings in seeking objective explanations of the universe (2d);
d) an appreciation that science is one of a number of ways of explaining the universe (3c, 3d);
e) curiosity about the accumulated body of scientific knowledge and the efforts of those who have contributed to it (2b);
f) an appreciation of the dilemmas that confront society as a result of scientific discoveries and of the difficulties involved in planning a course of action related to these discoveries (2d);
g) an appreciation of the way public knowledge of scientific advances is utilized in decision making (2f, 3e, 4b);
h) an appreciation that scientists have a role and responsibility in society with respect to the impact of scientific advances (2f);
i) an appreciation of the conflict and disagreement that may occur among scientists in terms of both the explanation and application of scientific knowledge (2b, 3b).

Skills. Students will have an opportunity to develop skill in:

a) acquiring information through personal research (2);
b) manipulating laboratory equipment and apparatus properly and safely (2a, 2e);
c) organizing numerical data in the form of graphs and charts and drawing conclusions from such data (2a, 2f);
d) designing simple experiments involving controls and numerical variations to test hypotheses (2a, 2e);
e) reporting findings from experiments and defending conclusions drawn from them (2a, 2e, 2f);
f) essay writing (2b-2d);
g) discussing and debating issues related to the nature of science and its role in society (2, 3, 4);
h) researching the development and extent of scientific knowledge at various stages of history (2f).

Knowledge. Students will be expected to:

a) explain the meaning of the following terms as they apply to science: hypothesis, knowledge claims theory, law, fact, inference, paradigm (2b, 2c);

b) research and report on the contribution of a scientist or scientists that resulted in a new way of thinking about a specific area of science. For example, they might examine the contribution of Mendel to the prevailing views on genetics or the contributions of Galileo to the prevailing views of the solar system. If possible, they should use the terms in (a) above in the report. Students should also include a brief description of the historical context in which this contribution occurred. At least one topic from *each* of the following lists is to be selected:

List A

- The theory of evolution
- The development of modern genetics
- The phlogiston-oxygen debate
- The development of insulin
- Bacteria as a source of disease
- A locally selected topic from the life sciences

List B

- The atomic model from Democritus to Schrodinger
- The development of particle physics
- The development of aeronautics
- The microchip revolution
- The development of the heliocentric model of the solar system
- The effect of Newtonian mechanics on astronomy
- A locally selected topic from the physical sciences (2c);

c) discuss the characteristics of classifying, which is common to all disciplines, using the periodic table as an example (2a);
d) describe the properties of representative elements from at least two groups from the periodic table and explain their similarities and differences (2a);
e) explain and illustrate the role of controlled experiments in scientific research (2a);
f) analyse data from experiments, such as those that measure the effect of various factors on plant growth (2a);
g) explain how the progress and development of scientific knowledge may have been influenced by social, economic, political, ethical/moral, and technological factors (2b-2f);
h) describe scientific developments that had a considerable impact on aspects of society in the past and indicate some that are having an impact in the present and others that may influence the future (2d-2f).

2. Student Activities

The student activities in this unit are to be used mainly to illustrate the fundamentals of scientific process in the laboratory. They should be designed to include research; design of experiments; experimental testing of hypotheses; quantitative work; analysis of data; the production of graphs and formulas, when appropriate; the interpretation of data; and the drawing of conclusions based on results. Additional activities, such as analysing appropriate research in an area, can be used to illustrate the development of scientific knowledge from a historical perspective, to determine the role of specific individuals in the development of a particular paradigm, or to assess the role and responsibility of science and scientists in society.

Students are to:

*a) perform at least two of the following laboratory activities: (i) an experiment that would lead to the development of a formula from quantitative data, such as the construction of a simple pendulum to determine the effect of mass, length, and displacement on the period; (ii) an experiment that would lead to the development of a pattern in the area of physical science, such as one that demonstrates the relationship of properties of elements to their relative location in the periodic table; (iii) an experiment from the area of the life sciences that investigates the growth process and that involves the use of experimental controls, such as the growing of some simple plants;
b) present a written report or seminar on how scientists work and on the factors that affect their work, such as political and social pressures, funding sources, public expectations, public respect for scientists, and their personal consciences;
c) present an oral or a written report in which they describe public reaction to a contribution of science that resulted in a new way of thinking about the area (e.g., Darwin's theory of evolution);
d) prepare a report describing the career and principal experimental work of a noted scientist, including his/her view of the role of science in society; *or* interview a scientist with respect to the type of work that he/she does, its purpose, the problems encountered, the way in which his/her discoveries are reported, and the impact of these discoveries on the scientific community and society;
e) using the experimental results or conclusions in a text or journal, design an experiment that would test these results or conclusions, *or* visit a laboratory and examine and report on the apparatus, techniques, and procedures involved in conducting experiments in various areas of science;

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*See the subsection entitled "Student Activities" on page 5.

f) conduct a survey to measure public knowledge of and attitudes towards science in our society, express the results in both numerical and written form, and analyse the results from such perspectives as the questions asked and the sampling techniques used.

3. Applications

a) Our changing views on the role of various foods in the human diet illustrate the tentative nature of science.
b) The careers and the attitudes of present-day scientists can be studied as examples of the human side of science. These careers and attitudes can be contrasted with those of scientists from the past.
c) The differing views of politicians, business people, farmers, and scientists on an issue such as acid rain illustrate the impact of science on society.
d) A study of the media presentation of science will help students understand how a distorted view of science could be gained by the public.

4. Societal Implications

a) Scientific literacy, including critical thinking skills and knowledge, will allow individuals to analyse and make decisions on scientific issues.
b) Scientifically literate individuals can assess the validity and usefulness of scientific information.
c) An understanding of the motives, attitudes, and other factors influencing the work of scientists can help individuals understand the direction of their work.

5. Evaluation of Student Achievement

Since an understanding of the nature of science and scientists, both past and present, is the principal aim of this unit, testing for factual recall should not form a large part of the evaluation process. Instead, the evaluation of student achievement should be based in large part on students' work in open-book tests, their oral or written reports, and their contributions to class discussions.

At least 60 per cent of the term mark for this unit is to be based on students':

a) analysis of experimental data;
b) research and reporting (oral and written);
c) laboratory activities.

6. Safety Considerations

Safety considerations in this unit depend on the experimental work selected. Reference should be made to the safety material in section 9 of Part 1 of this guideline. Students should learn to identify potential hazards and deal effectively with them. The following are examples of safety precautions:

a) Teachers should monitor student selection and performance of laboratory activities. Experiments with any safety concern, such as the use of chemicals or electricity, require careful supervision.
b) Students should tie loose hair back and use protective eyewear when performing experiments involving glassware or chemicals.

7. Possible Extensions

Some students might:
a) attempt to reproduce historical experiments under the original conditions;
b) investigate sources of funding for scientific research;
c) research government regulations for approval of new pharmaceuticals or study environmental testing;
d) investigate research and government programs aimed at benefitting persons suffering physical disabilities;
e) investigate the steps that have been taken to identify and obtain almost total eradication of a major disease (e.g., polio, smallpox, tuberculosis).

8. Some Teaching Suggestions

a) The laboratory exercises should be used as examples of scientific inquiry, rather than as verification of subject matter. They should encourage students to formulate hypotheses, design experiments, interpret data, develop conclusions, and analyse the role of experiments with regard to existing theories.
b) Students should be given practice in using a systematic approach to problem solving and decision making.
c) The historical origins of some scientific processes may be examined, and examples of current research used to illustrate processes that are employed today.
d) The process involved in the development of a scientific theory should be stressed.
e) An interdisciplinary approach should be used, with other staff members (e.g., those from the history, economics, geography, and technical areas) invited to visit the class to present their perspectives on a particular issue. These individuals may also be useful in suggesting sources of materials for discussion.

f) A classroom visit by a professional scientist, social scientist, philosopher of science, historian of science, or member of the clergy may be helpful in providing different views on a particular issue.
g) Students should investigate the role of the scientist in society by addressing questions such as the following: (i) Who provides and controls funding for scientific research? (ii) How does the public view scientists? (iii) What causes controversies among scientists? (iv) How are controversies between scientists and other sectors of society resolved? (v) How are scientific findings reported to the public?
h) The role of the media in reporting scientific issues can be demonstrated through examples taken from both the popular press and scientific literature.
i) Use should be made of visual resources such as films or documentaries to demonstrate the work of scientists in both social and historical contexts.
j) Debates on the responsibilities of scientists to society could be undertaken.
k) Students could write a story or play recreating the ideas, attitudes, and work of a scientist from the past.
l) The development of critical reading skills should be emphasized. In reading and reporting on research, students should recognize the importance of identifying the source and analysing the accuracy of the data (e.g., noting whether the source is a primary one, a secondary one, an autobiography, or a biography; the reputation of the author and the journal; possible sources of distortion).
m) One framework for looking at knowledge claims includes the following components: evidence (direct and indirect), truth strategies (correspondence and coherence), beliefs, and argument patterns (data, qualifiers, rebuttals, conclusions).
n) Journals and books on the history and philosophy of science will provide a background for the ideas in this unit.

Core Unit 2

The Nature of Technology

Time: 20 hours

This unit indicates means by which technology interacts with and has considerable impact on the economic, social, political, moral/ethical, and psychological spheres of civilization. The effects of technology in these areas in the past, present, and future will be explored.

This unit may be divided into topics such as the following:

- The meaning of *technology*
- Early technology
- Modern technology
- The impact of technological developments
- The relationship of technology to science
- Experiments that demonstrate the scientific principles underlying technological innovation

1. Objectives

Attitudes. Students will be encouraged to develop:

a) curiosity concerning various definitions of the term *technology;*
b) an interest in the origins of technologies;
c) an appreciation that technology may affect many areas of human activity (e.g., social, cultural, economic, political);
d) an appreciation that the impact of technology may be either beneficial or detrimental to humans;
e) an appreciation that the value of technology in a society may be perceived differently by various groups in the society;
f) an appreciation that technology has greatly influenced a major portion of our present society and lifestyle and may have a dominant impact on the future structure of society;
g) an appreciation of the effect that technologies have on our physical surroundings and natural environment;

h) an appreciation that many scientific disciplines may be involved in the development of a particular technology.

Skills. Students will have an opportunity to develop skill in:

a) locating, analysing, and discussing different viewpoints about the effects of technology on society (2b, 2d, 2e);
b) essay writing (2b);
c) critically discussing and debating issues (2b, 2e, 2f);
d) researching information in scientific and technical journals, newspapers, films, and documentaries (2d, 2i);
e) designing and performing experiments to demonstrate the scientific principles behind a technology (2a, 2c);
f) representing observations quantitatively (2a, 2f);
g) using diagrams to demonstrate the nature or workings of a technology (2a);
h) representing the development and impact of a technology by means of diagrams or flow charts (2i).

Knowledge. Students will be expected to:

a) define the terminology associated with a study of technology and its impacts, such as the following: technology, technological determinism, technological opportunism, technological innovation, technocracy, technofix (2, 8);
b) analyse the social, psychological, political, moral/ethical, and economic influences on the origins, development, and utilization of technologies by different societies (2b, 2d, 2f, 2i);
c) analyse the influence of various technologies (past, present, and future) on the nature of society (2b, 2d, 2f, 2i);
d) explain the societal and scientific origins of one technology;
e) explain the impact on the various segments of society of one technology;
f) indicate the scientific principles that underlie one technology;
g) explain why different societies in the past may have rejected innovations in technology;
h) identify and explain concerns that are expressed regarding contemporary technological changes;
i) explain the scientific principles underlying a technology (2a);
j) analyse and explain the important steps in the development of a technology (2b, 2i).

2. Student Activities

Students are to:

*a) conduct at least two experiments of a biological, chemical, or physical nature to demonstrate the scientific principles behind a technology, such as an experiment on refraction to demonstrate the technology of the microscope (6);
b) write an essay or present a seminar on (i) the origins, development, and uses of a modern technology or (ii) the political, economic, social, or cultural impact of a specific technology in the past, present, or future;
c) develop a working model of a specific technology;
d) assemble a bibliography of materials, both from the print and visual media, that discuss the societal impact of a specific technology; or present reviews of films or videos that deal with technology and society;
e) develop and implement a questionnaire or survey form to measure the public's awareness of and attitudes towards innovations in technology and analyse and report their findings to the class; or prepare a report on an interview with at least four senior citizens about the types of technological change that they have observed and have them indicate how such change affected their lives;
f) interview an individual in the technological field (e.g., an inventor, a manufacturer of high-technology products, or a salesperson in the high-technology area) about his/her work, his/her role in society, and the importance of his/her products; or interview or study the opinions of a commentator on technological issues (e.g., futurist, journalist, filmmaker, academic) with respect to the impact of technology and analyse his/her response in terms of possible sources of bias;
g) visit a technological site (e.g., factory, museum, laboratory, university) to observe technology in action;
h) write a short story, one-act play, or poem in which some aspect of the development or impact of a technology is portrayed;
*i) develop a time chart indicating the dates when various technologies were first used.

3. Applications

a) The direction and extent of scientific research is influenced by the technological ability of society. For example, the technology of the lens led to the telescope and the microscope, which in turn facilitated research in such areas as astronomy and medicine.
b) An understanding of the various implications of technological development may allow a society to control technological change better or to plan more effectively for the new social system that may be produced.
c) An understanding of different technologies assists social scientists in understanding the role of technology in the development of a society (8a).
d) Different sectors of a society are affected to a greater or lesser degree by technology. This will affect the amount and type of technology that is adopted.
e) Education systems may be modified to accommodate the impact of new technologies.
f) Technologies are the result of many different and unrelated factors, which may produce unexpected results both technically and socially.

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*See the subsection entitled "Student Activities" on page 5.

4. Societal Implications

a) Technologies may bring about changes in society that are unexpected or difficult to control and that often have both beneficial and detrimental effects.
b) Technology may cause a redistribution of wealth and power within a society.
c) Technology can create problems in the work force, such as unemployment and changes in the nature of work.
d) Technology may create dissension in society between those who desire it and those who do not.
e) The advent of new technology precipitates debates about who should control its introduction.
f) New technologies may either obscure or focus the future direction that society will take.
g) Technology has had and continues to have a tremendous impact on many aspects of our lifestyle (e.g., urbanization, communication, media, eating habits).
h) Technology may solve many modern medical problems, but it also poses increasingly difficult ethical/moral dilemmas such as test-tube babies, bioengineering, and the use of elaborate life-support systems.
i) Technology has created enormous destructive powers that affect humans and the environment (e.g., nuclear power, toxic waste, modern weapons).
j) Technology may shift power among nations, further separate the rich and poor nations, or reduce the barriers between the rich and poor nations.
k) Technology may create new social classes within society, based on the ability to manipulate technology.

5. Evaluation of Student Achievement

At least 60 per cent of the term mark for this unit is to be based on students':

a) experiments and hands-on work with a technology, such as those outlined in 2a;
b) class discussions and analyses of issues related to the origin, development, use, and effects of technology;
c) seminars;
d) written essays.

6. Safety Considerations

a) Students should take appropriate precautions when conducting individual experiments.
b) Planning should take place and precautions should be taken prior to visits to factories or laboratories.

7. Possible Extension

Some students might use the technology studies in this unit and in other units to examine environmental concerns or other issues.

8. Some Teaching Suggestions

a) Students should be encouraged to consider the impact of a technology on various areas of a society, as well as the scientific principles behind it.
b) Students should attempt to speculate about or imagine future effects of technology and how they will affect their lifestyles and job prospects.
c) Students should survey their peers, parents, and grandparents to determine their perceptions of how technology affects them. They should analyse their results in terms of the data-collecting technique used, questions asked, and variables and draw some conclusions about the reaction of different age, employment, and social groups to technology.
d) Excellent video materials on the subject of science and technology, featuring individuals such as David Suzuki and Alvin Toffler, are available for use from TVOntario. The views of the individuals in the class on the ideas presented in the videos should be noted, and students can then do assignments related to each video.
e) Excellent films on the subject of technology are available through school boards or public libraries and could be used effectively.
f) Students can prepare a scenario about the future impact of technology. This may take the form of an essay, a short story, a poem, a one-act play, or a short video.
g) Students can study reactions to technology in the print media. They might collect a number of articles, advertisements, or editorials representing as broad a range of viewpoints as possible about the impact of technology.
h) Class discussion and debate should be encouraged.
i) Experiments showing the scientific principles behind technologies can be individualized or carried out by the entire class.
j) Visits to factories, laboratories, and museums should be undertaken whenever possible so that students can observe the workings of technology first-hand and have the opportunity to interview experts in the field.
k) If possible, students should be encouraged to do a computer search to obtain a bibliography of materials.
l) In conducting a survey, students should be made aware of acceptable procedures, sampling techniques, limitations of the data, and the validity of their conclusions.

Core Unit 3

Humans in the Environment

Time: 20 hours

This unit focuses on developing problem-solving and decision-making skills within the context of environmental issues. The variety of factors, including political and economic ones, that enter into decisions that are made about environmental issues is emphasized. Knowledge claims are analysed with respect to the author's conceptual and values framework and societal concerns.

This unit may be divided into topics such as the following:

- The effect of human activities on the environment
- The effect of the environment on humans

1. Objectives

Attitudes. Students will be encouraged to develop:

a) a concern for the environment and its quality (2);
b) a concern for the problems caused by overpopulation (2g);
c) a commitment to becoming informed citizens who have the desire and ability to deal rationally with scientific and technological issues (2d);
d) an appreciation for societal expectations regarding the responsibilities and role of scientists in discussing major social issues (2f);
e) an understanding of how industry creates benefits for society and yet often creates problems as well (e.g., the chemical industry) (2d);
f) an appreciation of the way in which lifestyle has been influenced by industry and technology (2g);
g) an appreciation of the importance of energy in our lives (2h);
h) a concern about the potential problems caused by such factors as acid rain and modern military technology (e.g., nuclear weapons, nerve gas, bacterial warfare) (2a);
i) a commitment to acting responsibly to maintain and improve the quality of the physical environment (2e).

Skills. Students will have an opportunity to develop skill in:

a) analysing the impact of various types of pollution on life and developing strategies to deal with such problems as acid rain, phosphates, nitrates, sulphates, and particulate matter (2a-2c);
b) measuring the concentration in a system of a given chemical or material (2a);
c) interpreting information predicting the environmental effects of changes in the populations of living things, including humans (2g);
d) interpreting graphical and tabular information and arriving at conclusions based on various data (2g);
e) researching, using the full range of available resources in various media, a topic such as combustion, fertilization, corrosion prevention, pharmaceuticals, herbicides, or food additives (2d);
f) developing appropriate writing skills, including the use of proper references and bibliographies (2e);
g) discussing and debating issues (2g-2k);
h) reporting orally and presenting seminars (2e, 2g, 2i);
i) writing essays (2e).

Knowledge. Students will be expected to:

a) list changes in the population of living things, including humans (2g);
b) explain how changes in populations have been influenced by agricultural, industrial, and other forms of technological developments (2g);
c) discuss the effect that a growing human population has on the biosphere (2g);
d) select a specific technology from the field of transportation, communication, or industry (e.g., automobiles, railways, pipelines, telephones, assembly lines, plastics) and explain how this technology has altered our physical environment and lifestyle (2g);
e) explain how chemicals play a central role in our lives and indicate how their impact can be both beneficial and detrimental to the environment and our lifestyle. Students may consider such items as the role of fertilizers in food production and their effect on the environment, the uses and problems of DDT, radiation as a medical treatment and source of disease, the use of pharmaceuticals as cures and their dangers to individuals, and the use of plastics as a convenience and their contribution to toxic waste (2d-2f, 8k);

f) explain how a lifestyle of high energy consumption affects the environment (2e, 2i);
g) compare and contrast various sources of energy in terms of their cost, availability, environmental impact, and social implications in order to understand their advantages and limitations in a Canadian context (2e-2g);
h) explain the impact of modern military technology on humans and on the physical environment (2g);
i) suggest possible solutions to the problems posed, analysing the information available on the issue, the conceptual framework in which the problem was viewed, and the problem-solving strategy used (2e-2g).

2. Student Activities

Students are to:

*a) conduct an experiment to measure the concentration of some material, such as the pH of acid rain or of a lake, airborne particulates, or phosphates in a river or lake;
*b) perform experiments with various concentrations of different types of acids to determine their effects on plant life;
c) collect airborne particles over a twenty-four-hour period, study the particles, and try to identify their source; or determine the types of acids contained in samples of rain or snow or from a lake or a river;
d) visit a chemical or environmental laboratory, study how measurements of various substances are conducted, and note the methods and equipment used to perform various procedures; or study local, provincial, or federal environmental regulations and suggest ways in which they could be more effective (6d);
e) select articles and review films or television documentaries representing differing viewpoints on a specific topic, and write an essay, prepare a visual presentation, or make a presentation to the class as the basis for a class discussion or debate;
f) conduct a survey to determine public views on issues such as the environment or energy supplies, analyse the data, and formulate conclusions based on the survey; or interview representatives of various interest groups, such as industry, labour, government, farmers, or environmental groups, to obtain their views on issues such as the environment or energy supplies;
g) prepare a flow chart tracing the social, economic, environmental, and political impact of a particular piece of technology, such as the steam engine, the automobile, or the railway; or prepare a statistical analysis showing the relationship between population growth and the supply of food, energy, and raw materials, project these patterns into the future, and discuss the point of view for the analysis;
h) examine the characteristics of soils and landforms that must be considered in the selection of a waste-disposal site; or select a specific region and report on the type of energy facility that could be used to satisfy its power requirements;
i) report on requirements for the construction of an all-purpose waste-recycling plant, assessing the feasibility of the project, the merits of having the plant constructed, and the degree to which lifestyles would be altered by its construction.

3 . Applications

a) An awareness of the types and causes of pollution can help individuals to limit the amount of pollution and to improve the environment.
b) Technological developments have resulted in various changes in lifestyle, particularly in the fields of medicine, transportation, and communications.
c) The impact of a specific technology is difficult to determine.
d) A better understanding of the effects of chemicals may allow individuals to improve their personal health or lifestyle. For example, knowing the effects of chemical additives allows people to choose foods with fewer or no additives.
e) When individuals understand the environmental impact of recycling, the location of waste-disposal sites, and alternate forms of energy production, more knowledgeable decisions concerning these items may be made.
f) A knowledge of the environmental impact of various substances and practices will enable individuals to better understand and debate changes in legislation and regulations that will affect the quality of the environment.

4. Societal Implications

a) An increased awareness of the impact on the environment of new technologies can aid people in recognizing ways in which society can best plan to manage their impact.
b) Education may be needed to help people determine attitudes, policies, and lifestyles required for the maintenance of a healthy environment.
c) Individuals may need to contribute actively to debates on issues that affect the environment and to make their views known to government, industry, and special-interest groups.
d) A better understanding of the complex nature of solutions to environmental or energy questions is needed.

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*See the subsection entitled "Student Activities" on page 5.

5. Evaluation of Student Achievement

At least 60 per cent of the term mark for this unit is to be based on students':

a) quantitative data from activity 2a;
b) completion of two other suggested activities;
c) contributions to class discussions and debates.

6. Safety Considerations

a) Students should wash their hands after using chemicals.
b) A fume hood should be used when noxious vapours or chemicals are produced.
c) Teachers should instruct students on the proper handling of acids and bases.
d) When acids or bases are being used, the working area should be clean before and after use.
e) Appropriate planning should precede visits to laboratories or factories or other field trips.
f) Safety precautions should be emphasized when students take water samples from lakes and rivers.

7. Possible Extensions

Some students might:

a) report on the testing procedures required before a drug or chemical is sold to the public;
b) interview people associated with government agencies, labour unions, or public-interest groups to determine concerns about health and environmental hazards in the workplace;
c) invite representatives of different groups interested in a specific issue such as acid rain to address the class or to debate the various perspectives;
d) interview farmers to determine their views about the fact that their land usage and productivity have been affected by scientific and technological advances and to identify alternatives that would be available if these advances were not employed;
e) devise new modes of transportation that could conserve natural resources and reduce ecological damage and estimate the feasibility of developing and implementing this new technology.

8. Some Teaching Suggestions

a) Students should be encouraged to locate and consider materials that reflect a number of different viewpoints.
b) It should be emphasized that various forms of technology have both beneficial and detrimental aspects, both in the short term and in the long term.
c) Fact sheets available from government agencies, universities, or organizations such as Pollution Probe on selected topics from this unit should be obtained.
d) Existing or proposed legislation and political party platforms on topics suggested by this unit should be considered as sources of useful information.
e) A visit to a location that has been damaged by chemical pollution or acid rain (e.g., a lake, a pond, a forest, an agricultural site) can be an important field trip for this unit.
f) Students should be encouraged to deliberate on relevant issues in their community and to devise strategies for action.
g) A visit to an energy-producing facility to determine the types of technology involved, planned changes to the technology, and the environmental impact of the facility's operations should be considered.
h) Students should analyse their own lifestyle in terms of energy consumed, impact on the environment, and health.
i) The school librarian can advise students on, and help them acquire, publications relevant to their research.
j) Film libraries of the school board or public libraries as well as the resources of TVOntario and ONTERIS should be consulted, and a list of visual resources that are relevant to this unit developed.
k) The role of chemicals in society will be considered in greater detail in core unit 4. Thus, knowledge objective (e) may be integrated with "Chemicals in society" in that unit.

Core Unit 4

Current Issues in Science

Time: 30 hours

This unit focuses on applying problem-solving and decision-making skills to some current issues in science that are of interest and relevance to the students. The unit emphasizes the nature and the role of scientific knowledge in the context of the decision-making process. Reasons for disagreements among scientists and people from other sectors of the community and for controversies within the scientific community are also explored.

The intent of this unit is to encourage students to develop a broad-minded approach to the problems of science and society and to learn to consider ideas, attitudes, and suggestions from various sectors of society, such as the scientific, economic, political, and religious sectors. Students should be aware that there are a variety of legitimate approaches to issues and that a number of different conclusions may be reached, depending on the approach used.

This unit may be divided into topics such as the following:

- Chemicals in society
- Nuclear energy
- Biotechnology

1. Objectives

Attitudes. Students will be encouraged to develop:

a) an open-minded approach to solving problems (2);
b) an appreciation that there are different ways of approaching the same issue (2d, 2g, 2h);
c) a tolerance for approaches, perspectives, and views that differ from their own (2g, 2h);
d) a respect for the rights of all individuals in a society (2g, 2h);
e) an appreciation of the strengths and limitations of science (2);
f) an appreciation that appropriate solutions to problems should be based on a respect for the rights and dignity of all members of a society (2g, 2h);
g) a problem-solving approach to issues (2);
h) an appreciation that "solutions" to problems are often the result of compromises among a variety of viewpoints (2).

Skills. Students will have an opportunity to develop skill in:

a) researching and locating evidence from a variety of sources (2);
b) analysing and interpreting evidence;
c) reading reports, articles, and information packages critically in order to analyse knowledge claims (2b-2h);
d) discussing controversial issues objectively (2b, 2d, 2g, 2h);
e) making decisions based on a variety of considerations (2);
f) defending their decisions effectively (paying attention to clarity of concepts and validity of argument) in either oral or written form (2a);
g) identifying the strengths and limitations of science in dealing with societal issues (2).

Knowledge. The following list of knowledge objectives is common to all topics. Students will be expected to:

a) outline clearly all aspects of a particular issue involving science or technology (2a);
b) describe how scientific research may produce both desirable and undesirable effects (2a);
c) explain how a conflict involving science or technology arose (2f-2i);
d) explain how a particular issue is perceived by the public and how this differs from the perceptions of various interest groups (2g);
e) state both the positive and negative aspects of an issue with respect to its effect on society (i.e., do a risk-benefit analysis) (2a);
f) suggest alternative strategies for resolving a specific conflict or controversy (2a);
g) compare and contrast a conflict or controversy with others that have occurred previously (2g-2i);
h) explain the effect of a controversy on scientific research (2);
i) explain how different scientists reach different conclusions from the same body of knowledge (2h);
j) indicate the different levels of social involvement and awareness among scientists (2).

I. Chemicals in Society

This topic may be subdivided into a number of subtopics such as the following:

- Fertilizers, herbicides, and pesticides
- Chemicals in warfare
- Legal and illegal drugs
- Food additives
- Pharmaceuticals
- Performance-enhancing drugs
- Fuel combustion
- Transportation of chemicals
- Toxic waste
- Chemicals and the water supply
- Corrosion
- Chemicals and the quality of life

Students will be expected to:

a) define appropriate terms and provide examples (e.g., fertilizer, herbicide);
b) discuss the properties, composition, and toxicity of various chemical substances;
c) explain the positive uses or effects that these substances may have in society and indicate their degree of usage;
d) describe the negative impacts of, or the controversies surrounding, these substances;
e) describe social, political, or economic factors that are encouraging, discouraging, or significantly affecting the use or development of these chemicals and project possible future developments.

II. Nuclear Energy

Students will be expected to:

a) define *nuclear energy*;
b) explain how nuclear energy was first produced and the milieu of its origin;
c) describe several positive applications of nuclear energy (e.g., electricity generation, cancer treatment, radioisotopes) and indicate their effect on society;
d) describe the potential dangers of nuclear energy (e.g., meltdowns, radiation leaks, contamination, nuclear weapons);
e) compare different types of nuclear reactors with respect to their design, efficiency, and safety;
f) determine the possible consequences of eliminating nuclear energy from the power grid in Canada;
g) explain possible short- and long-term effects of nuclear warfare.

III. Biotechnology and Related Issues

Students will be expected to:

a) define the following: gene splitting, recombinant DNA, cloning, restrictive enzymes, genetic engineering;
b) explain the societal implications of the above scientific practices;
c) compare the arguments for and against utilizing and further developing the above knowledge;
d) describe biotechnology and life patents and indicate their uses and possible concerns over their use;
e) describe *in vitro* fertilization, organ transplants, and euthanasia and indicate concerns that arise from each procedure;
f) indicate other types of biotechnology in use today and questions posed by their use;
g) indicate the social, economic, and political pressures exerted both for and against biotechnology.

2. Student Activities

The materials in this unit do not lend themselves to a great deal of experimentation, but rather to library research, essay writing, oral reports, and classroom debate and discussion. Experiments may, of course, be included when appropriate, but issue analysis and the drawing of conclusions should be the principal focus of the unit. Students will be expected to produce a major written report or essay that analyses a particular issue and proposes solutions or indicates conclusions concerning the topic. In order to produce a satisfactory report or essay, students must investigate a wide range of print resources from libraries and the popular press, as well as the visual resources that are available. They should also be able to display a knowledge of the scientific and societal factors that have an impact on the selected issue and should be able to debate the conclusions they reach with their fellow students, either formally or informally.

Students are to:

*a) write a report or conduct a seminar on an aspect of one of the above topics;
b) consult either orally or in writing with an expert on the selected subject;
c) learn how to use the resources and information-retrieval techniques available at a library;
d) consult with a teacher from another subject discipline to acquire a different perspective on the issue and assistance in locating materials;

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*See the subsection entitled "Student Activities" on page 5.

e) review available films, documentaries, and videos in order to gain additional information and interpretations;
f) review various articles from the popular press in order to determine how accurately scientific and technological issues are reported to the public and attempt to assess the impact that these reports might have;
g) contact representatives of political parties and government officials in order to obtain a knowledge of existing and proposed legislation, regulations, or other policies that have an impact on the issue;
h) conduct a poll or survey of the public in order to measure present opinion about an issue;
i) attempt to discover whether any historical precedents or comparisons exist with respect to the issue they have selected.

3. Applications

a) Students' research and analytical skills can be applied to controversial issues in everyday life.
b) Skill in resolving an issue or problem, communicating one's conclusions, and defending one's viewpoints effectively is valuable both in academic and personal life.
c) Many sectors of society are concerned with the impact of science and technology and are looking for positive applications.
d) A high level of public awareness and understanding of problems is important to the resolving of difficult issues in science and technology.

4. Societal Implications

a) A thorough knowledge of the impact of science and technology in the past and present may help us to minimize or avoid future problems.
b) Science provides one of a number of possible explanations of natural phenomena.
c) Scientists are members of society and should not be viewed as being isolated from political and social activity.
d) All citizens should have as wide a knowledge of scientific and technological issues as possible so that they can contribute to informed decisions that may affect their way of life.

5. Evaluation of Student Achievement

At least 60 per cent of the term mark for this unit is to be based on students':

a) written papers and reports;
b) research and research notes;
c) class discussion and debate.

6. Safety Considerations

Safety considerations are not usually applicable to this unit.

7. Possible Extensions

Some students might:

a) examine lifestyles from the past and try to discover how a scientific discovery or a particular piece of technology such as a plough, a bathtub, or a fireplace affected people at the time in question;
b) examine how the recent introduction of a new technology or scientific discovery has affected the way of life in a developing country;
c) write an essay or story in which they try to imagine the impact of technology and science on the future world;
d) invite representatives of different groups (e.g., business, labour, the clergy, politicians, scientists) interested in a specific issue to explain their views;
e) visit a high-technology manufacturing facility, chemical plant, waste-management facility, or power station to discover the types of technology employed, the types of research being done, and the benefits and problems generated by the factory or the facility and investigate future plans for the development of products or processes;
f) complete a historical study of scientists to determine how their research might have been affected by the social, political, or economic factors of their times;
g) investigate the conditions that led to the acceptance or rejection of a particular piece of technology either in the past or the present;
h) investigate advertisements to determine to what degree science is used in the selling of products;
i) investigate examples of scientists who have suppressed discoveries or knowledge that they felt to be dangerous or harmful (e.g., Pythagoras, Pascal);
j) investigate the careers and opinions of scientists who have been outspoken on the relationship between science and society.

8. Some Teaching Suggestions

a) Teachers should consult with colleagues from other disciplines to gain assistance with materials, essay-writing techniques, and procedures for debates and seminars.
b) Consultation with the teacher-librarian can be beneficial in providing information on various topics and helping students improve their research skills.

c) Students should be encouraged to use as wide a variety of sources as possible – both academic and non-academic, print and visual.
d) Students should be presented with articles representing different viewpoints on a particular issue and asked to compare them and explain the differences. Oral questioning or a worksheet with a list of questions that students could answer would be effective methods of obtaining responses.
e) Students should be encouraged to use their imagination in conjunction with their knowledge of science and technology to describe how their future world may be affected by scientific and technological advances.
f) Students should visit an old factory, an agricultural museum, or a scientific museum in order to gain a knowledge of past technologies and scientific practices and to note changes over the years.
g) The impact of religion on science can be discussed in terms of the following positions:

  - Science and religion are totally independent.
  - Science and religion are mutually at variance.
  - Science and religion are compatible and complementary.

h) Students should be asked to bring in articles, advertisements, or cartoons that involve the reporting or representation of science to the public. They can analyse these materials in terms of their accuracy or bias and discuss the degree of influence that they might have on society.
i) TVOntario and the public libraries should be used as sources of relevant films or videotapes. Students should be asked to analyse the visuals with respect to content, theme, and credibility or to determine the viewpoints of their producers. A list of questions could be provided for students to consider while they are examining these materials.
j) The limitations of student polls or surveys as a valid data base should be stressed. Very often such a data base is small and not random, and as a result the interpretation of the data is subject to bias and misinterpretation. The nature of evidence and the need to analyse knowledge claims critically should be discussed with students.

Optional Unit

Locally Designed Unit

Time: 20 hours

This unit is to be designed at the local level as desired. It can be used to introduce a new area or topic of science not described in this guideline or to incorporate additional objectives that will expand a previous part or parts of the course. The following are examples of areas or topics that might be considered: science at work, scientists and their discoveries, energy, the limitations of science, health technologies. If a series of short topics is considered, these topics may be fitted into the course schedule from time to time throughout the semester or year.

This unit may provide an excellent opportunity for students to engage in independent study on a topic in science that is of particular interest to them and that is approved, monitored, and evaluated by the teacher. Students may work individually or in small groups. The unit could be started after students have had some experiences in the laboratory and are well aware of safety precautions.

It is expected that the local design of this unit will incorporate components similar to those adopted in the core units, namely, objectives, student activities, applications, societal implications, and safety considerations. An outline of the unit is to be included with the school's course of study and kept on file so that it is available to interested students and parents.

Appendixes

Appendixes

A. Science Courses and Their Course Codes

B. The Table of Contents of Part 1

Appendix A

Science Courses and Their Course Codes

The secondary school guideline courses in science authorized under this document have the following course codes:

Science, Grade 9, Basic Level	SNC1B
Science, Grade 9, General Level	SNC1G
Science, Grade 9, Advanced Level	SNC1A
Science, Grade 10, Basic Level	SNC2B
Environmental Science, Grade 10, General Level	SEN2G
Science, Grade 10, General Level	SNC2G
Environmental Science, Grade 10, Advanced Level	SEN2A
Science, Grade 10, Advanced Level	SNC2A
Science, Grade 11, Basic Level	SNC3B
Applied Biology, Grade 11, General Level	SBA3G
Applied Chemistry, Grade 11, General Level	SCA3G
Environmental Science, Grade 11, General Level	SEN3G
Biology, Grade 11, Advanced Level	SBI3A
Chemistry, Grade 11, Advanced Level	SCH3A
Science, Grade 12, Basic Level	SNC4B
Environmental Science, Grade 12, General Level	SEN4G
Geology, Grade 12, General Level	SGE4G
Applied Physics, Grade 12, General Level	SPA4G
Environmental Science, Grade 12, Advanced Level	SEN4A
Geology, Grade 12, Advanced Level	SGE4A
Physics, Grade 12, Advanced Level	SPH4A
Technological Science, Grade 12, General Level	STE4G
Biology, OAC	SBI0A
Chemistry, OAC	SCH0A
Physics, OAC	SPH0A
Science in Society, OAC	SSO0A

The following general rules govern science course codes:

- All science course codes begin with an **S.**
- **SNC** identifies a course that has only the name "Science".
- Where one word other than "Science" describes the course, the first two letters of that word follow the **S** (e.g., **SBI** means "Science, Biology" or simply "Biology"; **SEN** means "Science, Environmental" or "Environmental Science").
- Where two words other than "Science" describe the course, the initial letters of those words are used (e.g., **SCA** means "Science, Chemistry Applied" or simply "Applied Chemistry").
- The fourth character in the course code, **1**, **2**, **3**, **4**, or **0**, represents Grade 9, 10, 11, 12, or an OAC respectively.
- The fifth character represents the level of difficulty: **B** for basic, **G** for general, or **A** for advanced.

For further information on course codes, refer to the *Manual for the Common Course Code* (Toronto: Ministry of Education, Ontario, 1986).

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